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(54) **Enteral composition for diabetic patients**

(57) A composition and method for providing nutrition, or a nutritional supplement, to a diabetic patient. Pursuant to the present invention, a low carbohydrate, high fat enteral formulation is provided. The fat compris-

es, in part, medium chain triglycerides (MCTs). Preferably, the composition includes a high percent of mono-unsaturated fats, high amylose starch, and soluble dietary fiber.

EP 0 691 079 A2

Description

The present invention relates generally to compositions and methods of treating diabetes. More specifically, the present invention relates to a method for providing nutrition, or a nutritional supplement, to a patient having diabetes without substantially increasing blood glucose levels.

Diabetes Mellitus is a chronic disorder affecting carbohydrate, fat, and protein metabolism. It is characterized by hyperglycemia and glycosuria resulting from a defect or deficient insulin secretory response. The number of patients diagnosed as diabetic was estimated in 1985 to be 10 million in the United States alone, with the figure increasing at a rate of 6% per year. Two major variants of the disease exist.

One variant, seen in about 10% of all idiopathic diabetics is referred to as insulin dependent diabetes mellitus (IDDM) or juvenile onset diabetes. This variant is frequently manifested for the first time in youth and is characterized by progressive loss of insulin secretory function by beta cells of the pancreas and hence a progressive "dependency" on exogenous insulin for the maintenance of carbohydrate metabolism. (This characteristic is shared by those non-idiopathic, or "secondary" diabetics whose disorder have their origins in pancreatic disease.)

The second variant of idiopathic diabetes is referred to as non-insulin dependent diabetes mellitus (NIDDM) or adult onset diabetes mellitus. This variant accounts for the remainder of the idiopathic diabetic population.

All diabetics, regardless of their genetic and environmental backgrounds or age of onset of the disease, have in common an apparent lack of insulin or inadequate insulin function. Because transfer of glucose from the blood to the muscle and fat is insulin dependent, diabetics lack the ability to utilize glucose adequately. Further, because glycogenolysis is ordinarily inhibited by insulin, the rate of glycogenolysis is elevated in diabetics. Both of these "derangements" from normal metabolic events lead to the accumulation of glucose in the blood (hyperglycemia) to the point where renal glucose reabsorption capacity is exceeded and glycosuria occurs. A major source of energy for the diabetic becomes fatty acids derived from triglycerides stored in fatty tissue.

In the liver, fatty acids are oxidized to ketone bodies which are circulated and used as an energy source by the tissues. In the IDDM patient and sometimes the NIDDM patient, the rate of formation of the ketone bodies may exceed their rate of utilization and ketosis along with metabolic acidosis may occur.

Since tissues appear to be starving for glucose, dietary tissue sources of protein are used in glycogenesis. Anabolic processes such as synthesis of glycogen, triglycerides and proteins are "sacrificed" to catabolic activities including glycogenolysis, gluconeogenesis and mobilization of fats. Thus, the diabetic state which has its origins in a "simple" insulin defect, results in widespread metabolic disturbances having long term pathological effects on nearly all organs and tissues of the body. Indeed, the diabetic state is one of the prime contributors to deaths caused by myocardial infarction, renal failure, cerebrovascular disease, atherosclerotic heart disease, and systemic infections.

The hyperglycemic and glycosuric conditions of the diabetic disease may be treated by a manipulation of the diet, control of body weight, and regulation of physical activity. In some diabetics, particularly those suffering from NIDDM, the hyperglycemic and glycosuric conditions can be treated by oral administration of anti-hyperglycemic agents such as derivatives of sulfonyleureas, sulfonamides, biguanides and other compounds. For diabetics suffering from IDDM and advanced NIDDM, however, therapy has focussed on administration of exogenous insulin.

Of course, the nutritional management of diabetes is of great concern. The American Diabetes Association has published guidelines for nutritional management of diabetes mellitus. These guidelines suggest that sufficient calories be given to a patient to achieve and maintain reasonable weight.

Pursuant to the ADA (1986 Guidelines), the diet may include up to 55%-60%, based on calories, as carbohydrates. The protein content of the diet recommended for people with diabetes is approximately 12%-20% of the total calories. The fat content of the diet is recommended to be less than 30% of the total calories. Of this polyunsaturated fats are recommended up to 10%, saturated fats recommended at less than 10%, and mono-unsaturated fats will make up the remaining percentage of the fat at a range of 10%-15%.

ADA guidelines 1994 revision are more flexible regarding percentage of calories from carbohydrates, but emphasize even further the need for an adequate lipid intake.

In many situations, it may be necessary to support a diabetic patient with an enteral diet or supplement. These diets can either be administered through a nasogastric tube or other external means or provided in a liquid form that the patient drinks. Such formulations may be necessary when patients are hospitalized and/or in other situations where the patients are unable to meet necessary dietary requirements without a nutritional formulation or supplementation.

Presently, a formulation on the market for a diabetic patient is Glucerna® sold by Ross Product Division, Abbott Labs. See U.S. Patent No. 4,921,877. Glucerna® provides approximately the following macronutrient profile: protein 16.7% of the calories; carbohydrate 33.3% of the calories; fat approximately 50% of the calories. The fat in Glucerna® is provided solely through long-chain triglycerides. Specifically, the fat is provided as 85% of the calories being safflower oil and 15% of the calories being soybean oil. The caloric density of Glucerna® is approximately 1 cal/ml.

The inventors of the present invention do not believe that presently available formulations satisfactorily meet the nutritional needs of the diabetic patient.

This invention provides a composition and the use of the composition for providing nutrition, or a nutritional supplement, to a diabetic patient. Pursuant to this invention, a moderate to low carbohydrate, high fat enteral formulation is provided.

Accordingly, this invention provides an enteral composition for providing nutrition to a diabetic patient without substantially increasing blood glucose levels, the composition comprising a protein source, a carbohydrate source, and a fat source that includes medium chain triglycerides and has an n-6:n-3 ratio of not more than 10.

In another aspect, this invention provides the use of a protein source, a carbohydrate source, and a fat source that includes medium chain triglycerides and has an n-6:n-3 ratio of not more than 10, in the preparation of an enteral composition for providing nutrition to a diabetic patient without substantially increasing blood glucose levels.

The invention allows reduced insulin to metabolize the "meal" and reduces the sensitivity to dose and timing of insulin to blunt the post-prandial serum glucose excursion. Additionally, due to the content of the formulation, improvement in the patient's tolerance to the formula is achieved.

Preferably the protein source provides about 8 to about 25% by weight of the calories of the composition.

Preferably the carbohydrate source provides less than about 50% by weight of the calories of the composition.

Preferably the fat source provides about 30% to about 50% of the calories of the composition. The fat source preferably comprises long chain triglycerides and medium chain triglycerides; the ratio of long chain triglycerides to medium chain triglycerides being about 4:1.

The composition preferably includes a dietary fiber; more preferably soluble and insoluble dietary fibers.

In an embodiment, the composition includes high amylose starch.

In an embodiment, the fat source of the composition comprises approximately 40% to about 70%, by calories, mono-unsaturated fatty acids.

In an embodiment, the composition includes at least one component chosen from the group consisting of sucrose, fructose, maltose, sorbitol, or xylitol.

In an embodiment, the composition is administered to the diabetic patient through a nasogastric tube.

In an embodiment, the composition is administered as a supplementation or a sole source of nutrition to the diabetic patient.

In an embodiment, the diabetic patient is non-insulin dependent.

In an embodiment, the diabetic patient is insulin dependent.

In an embodiment, the fat source comprises, by calories, at least 4% essential fatty acids.

In an embodiment, the composition provides at least 100% of the U.S. RDA of all vitamins and minerals per 1500 Kcal.

An advantage of the present invention is it provides an improved composition for providing nutritional requirements and/or support to a patient having diabetes.

Furthermore, an advantage of the present invention is that it provides a method for providing nutrition to a patient having diabetes.

Additionally, an advantage of the present invention is that it provides a method and composition for providing nutrition to a diabetic patient without substantially increasing blood glucose levels.

Still further, an advantage of the present invention is that it provides a composition specifically directed to the meet the nutritional requirements and needs of the diabetic patient.

A further advantage of the present invention is to provide a composition that includes, in an embodiment, high amylose starch that is digested at a slower rate than other starches and thereby leads to a reduction in the rate at which glucose enters the blood stream.

Additionally, an advantage of the present invention is that the use of high amylose starch enhances glycemic control in the diabetic patient.

Moreover, an advantage of the present invention is to provide a fat source having an n-6:n-3 ratio that improves immune response.

Furthermore, an advantage of the present invention is to provide a formulation having dietary fiber that will tend to slow down the metabolism of carbohydrates in the formula.

Additional features and advantages of the present invention are described in, and will be apparent from, the detailed description of the presently preferred embodiments.

The present invention provides a composition and method for meeting the nutritional requirements of a diabetic patient. Pursuant to the present invention, a composition is enterally administered to the patient. The composition of the present invention is a moderate to low carbohydrate, high fat enteral formulation including a protein source, a carbohydrate source, and a fat source having an MCT content. By reducing the carbohydrate intake and substituting therefor MCTs, the composition reduces the insulin necessary to metabolize the meal. Additionally, the composition reduces sensitivity to dose and timing of insulin to reduce the post-prandial serum glucose excursion. The present invention provides benefits in improved tolerance, metabolic and glucose management/insulin requirements and additional advantages.

An advantage of the present invention is provided by non-glucose, non-insulin dependent alternatives to carbohydrates in an enteral product for diabetes. The present invention avoids disadvantages of many current products and minimizes the increase in blood glucose and the associated insulin requirement which follows feeding of these patients.

In an embodiment, another advantage of the present invention is that it provides a formula including dietary fiber that will slow down the metabolism of the carbohydrates in the formula. Additionally, the use of a high amylose starch in the formula will lead to a reduction in the rate at which glucose enters the blood stream. Because it is resistant to digestion by pancreatic enzymes, the high amylose starch of the composition of the present invention enhances glycemic control in the diabetic patient. An advantage of the formula of the present invention is that it provides a composition having a low carbohydrate content and high amylose starch that is slowly digested.

The fat source preferably comprises approximately 30% to about 50% of the total calories of the composition. In a preferred embodiment, 30% to about 44% of the calories are derived from the fat source. The fat source comprises long chain triglycerides (LCTs) and medium chain triglycerides (MCTs).

MCTs can be a mixture of C6-C12. For example, MCTs can be a mixture of C6:0(1-2%), C8:0(65-75%), C10:0(25-30%), and C12:0(1-2%). In an embodiment, the MCTs comprise 20% of the fat source and LCTs comprise 80% of the fat source.

The use of MCTs aids in digestion. Digestion of MCTs may be easier than LCTs in that LCTs are digested by various lipases; in contrast to LCTs, pancreatic lipase is not essential to digestion of MCTs. Additionally, absorption of MCTs is faster as compared to LCTs. LCTs require incorporation into chylomicron by intestinal mucosal cells. Similarly, transport of MCTs is via portal circulation directly to the liver whereas LCTs are transported via lymphatics and systemic circulation before finally ending up in the liver. LCTs are oxidized more slowly requiring carnitine for entry into the mitochondria. The source of MCTs can comprise fractionated coconut oil.

Preferably, the LCTs are provided as canola oil, olive oil, and hi-oleic safflower oil. Although other oils can be used such as, e.g., soy oil, high-oleic sunflower oil, or any oil rich in mono-unsaturated fatty acid (MUFA). These oils not only provide linoleic acid, an essential fatty acid, but also provide n-3 fatty acids. Linolenic acid, the predominate n-3 fatty acids supplied by these oils, may serve as a precursor to other n-3 fatty acids which have anti-inflammatory activity. Preferably, at least 4%-10%, by calories, essential fatty acids are provided by the composition of the present invention.

Preferably, in an embodiment, the ratio of n-6:n-3 fatty acids is approximately 4. However, other ratios can be used with preferably the ratio of n-6:n-3 being 2 to 10. This lower ratio improves the immune response.

Additionally, the fat source comprises approximately 40% to about 70% of the total calories as mono-unsaturated fatty acids (MUFA). In a preferred embodiment, the MUFA content of the fat is approximately 58% by caloric content. This higher level of MUFA as part of a high fat/moderate carbohydrate diet provides lower serum lipids than a lower fat diet that does not contain a significant amount of MUFA. An advantage of the composition of the present invention is that it provides a high fat diet with MCTs and a high content of MUFAs.

Pursuant to the present invention, preferably the composition provides 8 to about 25% of the total calories as a protein. Preferably, the formulation contains caseinate, whey protein, or non-fat milk as the protein source.

Preferably the composition comprises approximately 30 to less than 50% in total calories as a carbohydrate and most preferably approximately 40% as a carbohydrate. A variety of carbohydrates can be utilized such as maltodextrins or other complex polysaccharides. If desired, the carbohydrates can be substituted for, in part, by fructose, sucrose, maltose, sorbitol or xylitol. This will provide non-glucose, non-insulin dependent alternatives which provide carbon skeletons to be used as an energy source.

Preferably, the carbohydrate component will comprise in part starch. Preferably, the composition will include a high amylose starch. A high amylose starch provides advantages over, for example, an acid modified starch. A high amylose starch will break down much more slowly than an acid modified starch and is digested more slowly as well. This leads to a reduction in the rate at which glucose enters the blood stream.

In a preferred embodiment, the high amylose starch will consist of approximately 25 to about 75% amylose and approximately 25% to about 75% amylopectin. In a most preferred embodiment, the amylose starch will consist of approximately 70% amylose and approximately 30% amylopectin.

In a preferred embodiment, the high amylose starch will comprise approximately 1% to about 5% of the composition; approximately 10 to 50 g/L of the composition. In a most preferred embodiment, the high amylose starch will comprise approximately 2.1% (23 g/L) of the composition.

Additionally, the composition, in a preferred embodiment, will include dietary fiber. The addition of dietary fiber to the formula tends to slow down the metabolism of the carbohydrates in the formula. Preferably, the composition includes approximately 8 grams to about 25 grams per liter of the composition as dietary fiber.

The dietary fiber will preferably include both soluble and insoluble fiber. Preferably, the soluble fiber will comprise approximately 50 to about 75% of the fiber present. In a most preferred embodiment, the soluble fiber will comprise approximately 70% and the insoluble fiber will comprise 30% of the total fiber content.

Preferably, the formulation will provide 100% of the U.S. RDA in 1500 kcal of all vitamins and minerals. Additionally, preferably, the present invention provides 1.0-1.5 kcal/ml.

The composition can include a surfactant. A variety of surfactants can be used such as egg yolk phospholipids, soy phospholipids, and milk phospholipids.

By way of example and not limitation, an example of the present invention will now be given. The formulation is intended for a diabetic patient. The formulation can be fed by mouth or by tube or can be used as a supplement or as a complete diet.

EXAMPLE

Nutrient	Source	Unit	US Diabetic (Per Liter)
Caloric Density		Kcal/ml	1.0
Protein	(18% Cal)	g	45
	Caseinates	g	45
Fat	(42% Cal)	g	50
	MCT	g	10
	Canola oil	g	18.5
	Hi-Oleic Safflower	g	18.0
	Soy Lecithin	g	3.5
	n-6:n-3 ratio		3.5
	MCT/LCT = 20/80		
CHO	(40% Cal)	g	100
	Maltodextrin	g	45
	High amylose starch	g	23
	Fructose	g	22
	Pectin	g	3
	Soy fiber	g	5
	Gum Arabic or guar	g	7

	Dietary Fiber		g	15
5	Flavoring			Vanilla
	Lactose			Lactose free
	Vitamin A		IU	4000
10	Beta-carotene		mg	2
	Vitamin D		IU	320
	Vitamin E		IU	30
15	Vitamin K		mcg	50
	Vitamin C		mg	140
	Folic Acid		mcg	400
20	Thiamine		mg	2
	Riboflavin		mg	2.4
	Vitamin B6		mg	4
25	Vitamin B12		mcg	8
	Niacin		mg	28
	Biotin		mcg	300
30	Pantothenate		mg	14
	Choline		mg	400
	Calcium		mg	720
35	Phosphorus		mg	720
	Magnesium		mg	286
	Iodine		mcg	120
40	Manganese		mg	3
	Copper		mg	1.5
	Zinc		mg	15
45	Iron		mg	12.8
	Sodium		mg	740
	Potassium		mg	1400
50	Chloride		mg	1200

Selenium		mcg	75
Chromium		mcg	125
Molybdenum		mcg	200
Carnitine		mg	100
Taurine		mg	100
M-Inositol		mg	800
	Comments		
Osmolality:	425 mOsm/kg water max.		
Viscosity:	90 CPS max.		
Packaging:	cans or bags		
Processing:	UHT aseptic or Retorting		

By way of comparison, a comparison of the diabetic formula of the present invention vis-a-vis Glucerna® from Ross is set forth below.

		<u>Present Invention</u>	<u>Ross Glucerna®</u>	<u>Comments</u>	
Caloric Density:	Kcal/mL	1	1.06		
Caloric Distribution:				ADA Guideline (1986)	ADA Guideline (1994)
Protein	%	18	16.7	12 - 20	10 - 20
Fat	%	42	50	<30 (< 10% saturated)	< 10% saturated
CHO	%	40	33.3	55 - 65	

					<u>Present Invention</u>	<u>Ross Glucerna</u>
5	Protein Composition:					
	Total Protein	g/L	45	41.8	100% Casein	100% Casein
10	Fat Composition:					
	Total Fat	g/L	50	55.7		
	MCT	g/L	10	0	MCT/LCT = 20/80	No MCT
15	LCT	g/L	40	55.7	Canola hi-oleic safflower	Soy hi-oleic safflower
	Fatty Acids Profile:					
20	MCT	%	18	0	7.6% of TEI	0% of TEI
	LCT	%	7.6	11.2	3.3% of TEI	5.6% of TEI
	Saturated	%	7.6	11.2	58%	76%
	Mono-	%	57.8	76.1	of fat calories	of fat calories
25	Unsaturated	%	17.1	12.7		
	Poly-	%	3.5	14		
	Unsaturated	%	7.2	7.1	EFA:7.2% of TEI	EFA:7.1% of TEI
	n6:n3 Ratio	%				
	EFA	%				
30	Carbohydrate Composition:					
	Total CHO's	g/L	105	93.7		Total includes all fibers
35	Total available CHO's	g/L	100	83.3		
40	High amylose Starch	g/L	23	0	Resistant to digestion	Contains no starch
	Maltodextrin	g/L	45	44.4		
	Fructose	g/L	22	17.7		
	Soluble fibers	g/L	10	0.75		
45	Insoluble fibers	g/L	5	13.65		
	Lactose	g/L			Lactose-free	Lactose-free

**Dietary Fiber
Composition:**

5	Total D.				Soluble:	
	Fibers	g/L	15	14.4	Insoluble=2:1	95% insoluble
	Pectin	g/L	3	-	Note:soluble fiber	
	Gum Arabic	g/L	7	-	slows ↓ digestion	
	Soy fiber	g/L	5	14.4		
10	Vitamins: Meet 100%					
	USRDA's in Kcals:		1400	1422		
	Minerals: Meet 100%					
	USRDA's in Kcals:		1400	1422		
15	Trace Nutrients include Cr, Mo, Se, Taurine, Carnitine, m-Inositol					
					"Cr" improves	
	Chromium:	mcg/L	125	124	glucose tolerance	
20	Flavoring		Vanilla	Vanilla		
	Taste		Sl. sweet	Sl. sweet		
	Osmolality		400	375		

By way of example, and not limitation, a contemplative example of the use of the formulation will now be given.

25 **CONTEMPLATIVE EXAMPLE**

A 45 year old insulin dependent diabetic female patient is admitted to the Intensive Care Unit with severe head trauma and multiple other injuries following an auto accident. She is unconscious and will require tube feeding of an enteral formula to meet her basic and stress nutritional needs. Standard enteral tube feeding formulas with only malto-

dextrin will produce high levels of blood glucose, increase insulin requirements, and make her diabetes hard to control during her recovery from the accident. Standard formulas with only long chain triglycerides are less well tolerated, absorbed less well, and metabolized more slowly.

Instead of a standard enteral tube feeding formula, she is administered by tube the formula of the present invention. The formula is administered until the patient can satisfy her caloric requirements through a normal diet.

The high amylose starch and medium chain triglycerides of this invention serve to blunt the increase of blood sugar and make her diabetes easier to control. In addition, the MCTs are more easily and rapidly absorbed, and are better transported, metabolized, and utilized as an energy source with better gastrointestinal tolerance, all of which are of a significant benefit to this type of patient.

It should be understood that various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the art. Such changes and modifications can be made without departing from the spirit and scope of the present invention and without diminishing its attendant advantages. It is therefore intended that such changes and modifications be covered by the appended claims.

45 **Claims**

1. An enteral composition for providing nutrition to a diabetic patient without substantially increasing blood glucose levels, the composition comprising a protein source, a carbohydrate source, and a fat source that includes medium chain triglycerides and has an n-6:n-3 ratio of not more than 10.
2. An enteral composition according to claim 1 in which the protein source provides about 8% to about 25% by weight of the calories of the composition.
3. An enteral composition according to claim 1 in which the carbohydrate source provides less than about 50% by weight of the calories of the composition.
4. An enteral composition according to any one of claims 1 to 3 in which the fat source provides about 30% to about 44% of the calories of the composition.

5. An enteral composition according to any one of claims 1 to 4 which further comprises high amylose starch.
6. An enteral composition according to claim 5 in which the high amylose starch comprises about 25 to about 75% by weight amylose and about 75% to 25% by weight of amylopectin.
7. An enteral composition according to any one of claims 1 to 6 in which the fat source comprises about 40% to about 70% mono-unsaturated fats.
8. An enteral composition according to any one of claims 1 to 7 in which the fat source comprises long chain triglycerides and medium chain triglycerides; the ratio of long chain triglycerides to medium chain triglycerides being about 4:1.
9. An enteral composition according to any one of claims 1 to 8 in which the fat source includes an oil selected from olive oil, canola oil, high-oleic safflower oil, high-oleic sunflower oil, and mixtures thereof.
10. An enteral composition according to any one of claims 1 to 9 in which the composition further comprises soluble and insoluble dietary fiber.
11. The use of a composition according to any one of claims 1 to 10 in the preparation of a medicament for enterally providing nutrition to a diabetic patient without substantially increasing blood glucose levels.